

Fungal Flora in Foot-Wear

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A survey of fungi on footwear was made. *Aspergillus niger* and *A. fumigatus* were found to be predominant species. *A. sydowi*, *A. japonicus*, *A. flavus*, *A. nidulans* and *Penicillium sp.* were frequently seen. Both water and sweat solubles of leather formed good substrates for mould growth, the growth on sweat solubles being more than on that water solubles.

It is well known that the tan liquors¹⁻¹¹ as well as leathers¹¹⁻²⁵ support mould growth. Hence the footwear made of such leathers are susceptible to mould growth. The fungal flora on footwear largely depends on the environmental factors. It may be interesting to know the type of fungi present in ladies footwear since in India ladies usually wear open type of chappals. It is also of interest to know the constituent of footwear that supports the growth of fungi. In the present investigation various moulds present in footwear from Madras city, were isolated and identified. The effect of water solubles and sweat soluble of leather on their growth was also studied.

Materials and Methods

The fungi from the footwear were isolated by swabbing the inside of the footwear thoroughly with a sterile moist cotton which was shaken in 10 ml of sterile water in a test tube. Dilutions (10, 100, 1000 and 10,000 times, the original solution) were made and 0.2 ml of each of these dilutions were transferred to sterile petridishes. 25 ml of Czapek's agar medium were added to each and the dishes were incubated for 5 days at $30 \pm 2^\circ \text{C}$. The fungi that developed were isolated and identified.

Composition of artificial sweat (g/litre) Urea 1.67 ; Sodium lactate (60%) 100.0 ; Disodium phosphate 0.417 ; sodium chloride 9.75 ; pH 6.5.

10 g leather freed from oils and fats by extraction with petroleum ether, was extracted with 200 ml of distilled water or artificial sweat, to get water solubles or sweat solubles, in a shaker (55-60 rpm) for 2 hr. These solubles were filtered and 20 ml portions of these were sterilised in 100 ml Erlenmeyer flasks. Spore suspension of the respective fungi in sterile distilled water, were obtained from 10 day old cultures on Czapek slants and 0.2 ml portions of a uniform suspension served as the inoculum. After incubation for 10 days at $30 \pm 2^\circ\text{C}$ the mycellial pads were harvested, washed free of soluble matter, dried at 60°C overnight and weighed.

Results and Discussion

Table 1 shows that the footwear in use contained species of fungi, that were also recorded either on tan liquor or on leathers. These might have

TABLE 1
Earlier and present record of species of *Aspergillus*, *Penicillium* and *Alternaria* occurring on the liquor, leather and footwear.

	Tanliquor	Leather	Footwear
<i>A. sydowi</i>	—	Krishnamurthi ²⁴	+
<i>A. nidulans</i>	Krishnamurthi ²⁸	Martin ²⁹	+
<i>A. japonicus</i>	Krishnamurthi ²⁸	—	+
<i>A. niger</i>	Krishnamurthi ²⁸ Knudson ¹	Musgrave ^{14, 15} Krishnamurthi ²⁴ Cordon ^{13, 22} Wilson ¹⁶	Green ³⁰ +
<i>A. fumigatus</i>	George ⁴	Othmann and Highy ⁹ Cordon ¹³	+
<i>A. flavus</i>	Krishnamurthi ²⁸ George ⁴	Krishnamurthi ²⁴ Musgrave ¹⁵ , Cordon ¹³	
<i>A. terreus</i>	Krishnamurthi ²⁸	Krishnamurthi ²⁵ Musgrave ¹⁴ Cordon ¹³	
<i>Paecilomyces varioti</i>	—	Cardon ¹³	
<i>Penicillium</i> sp.	Chambard ³	Cardon ^{13, 22} Wilson ¹⁶ Mitton ¹⁷ Sen ³¹ , George ⁴ Raper ³²	Greene ³⁰
<i>Alternaria</i> sp.	—	—	Gerene ³⁰ +

+ reported first time on footwear in India

come from both these sources to the foot-wear, while the possibility of contamination from surroundings cannot be ruled out. The table also shows the presence of *Alternaria* sp. and *Paecilomyces varioti* in addition to those that were found in tanliquors or leathers. The fungi present in footwear varied from person to person. The variation in the fungal flora seen in different footwear revealed that the presence of fungi in footwear depended mainly upon the materials used in the processing of leather and the surroundings in which the footwears were worn. It may also be observed that the presence of fungi did not depend upon the type of footwear, whether shoe, sandal or chappal. From Table 2, it may be seen that *A. niger* and *A. fumigatus* were

TABLE 2
Occurrence of various fungi in men's and women's footwear

Species	Men's shoes	Men's sandals	Women's chappals
<i>A. niger</i>	82	100	100
<i>A. fumigatus</i>	76	100	67
<i>A. terreus</i>	18	—	—
<i>A. sydowi</i>	35	—	—
<i>A. japonicus</i>	24	—	33
<i>A. flavus</i>	6	—	33
<i>A. nidulans</i>	12	40	33
<i>Paecilomyces varioti</i>	6	—	—
<i>Penicillium</i> sp.	35	20	—
<i>Alternaria</i> sp.	6	20	—

Figures are ratios of the number of cases where the fungus was present to the total number observed expressed as percentage

predominant. In men's shoes *Penicillium* sp. *A. sydowi* and *A. japonicus* were frequently found. *Penicillium* sp., *A. nidulans* and *Alternaria* sp. were also quite frequent in men's sandals. The occurrence of the above species in tropical and subtropical climates on soils and decomposing organic materials is well known²⁶.

Growth of fungi on water solubles and sweat soluble of leather (mat wt. in mg)

Source	<i>A. niger</i>		<i>A. fumigatus</i>		<i>A. sydowi</i>		<i>Alternaria</i> sp.		<i>Penicillium</i> sp.	
	W	S	W	S	W	S	W	S	W	S
Sole leather	16.0	29.2	15.8	39.2	20.4	79.0	16.0	24.8	16.7	19.4
E. I. goat	16.7	29.8	12.3	17.8	16.9	67.3	13.2	35.0	14.8	17.0
E. I. sheep	18.4	31.3	14.2	26.4	18.2	81.2	15.1	26.0	13.4	16.1
Chrome retanned with cutch	10.8	14.4	10.7	16.0	11.5	49.1	11.2	21.1	10.1	16.4
Chrome retanned wattle	10.2	14.7	10.1	15.1	10.2	54.2	11.6	22.4	8.7	13.4

The growth of fungi on water solubles and sweat solubles of leathers is presented in Table 3. It is observed that water solubles from vegetable tanned leathers supported the growth of fungi better than water solubles from retanned leathers. This may be attributed to low percentage of water solubles, in retan leathers (Table 4). It can, therefore, be suggested that water soluble-

TABLE 4
Water solubles of leather

Type of leather	% on leather
Sole (veg)	11.00
E.I. goat	6.37
E.I. sheep	10.08
Chrome retanned with cutch	3.90
Chrome retanned with wattle	1.61

in leather is one of the main sources of nutrition for fungal growth. The removal of water solubles by soaking, greatly reduced the mould growth²⁷. It is also seen that the growth of fungi on sweat solubles was more than that on water solubles. This may be due to the presence of nitrogenous materials and mineral ions in addition to the usual nontans from leather. It is likely that the worn shoes are more susceptible to mould growth since constituents of sweat can accumulate in them.

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